FORM-PTO-1390 (Rev. 9-2001)	U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE	ATTORNEY'S DOCKET NUMBER
TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371		004501-653
		U.S. APPLICATION NO. (If known, see 37 C.F.R. 1.5) Unassigned 10/089606
INTERNATIONAL APPLICATION NO. PCT/CH00/00459	INTERNATIONAL FILING DATE 30 August 2000 (30.08.2000)	PRIORITY DATE CLAIMED 1 October 1999 (01.10.1999)

TITLE OF INVENTION
SENSOR COMPRISING WIRELESS DATA TRANSFER UNIT WITH A LOW POWER UPTAKE

APPLICANT(S) FOR DO/EO/US
RAMSEIER, Stefan; DZUNG, Dacfey; KJESBU, Snorre; APNESETH, Christoffer; VEFLING, Harald

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. ☒ This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. ☒ This is an express request to begin national examination procedures (35 U.S.C. 371(f)). The submission must include items (5), (6), (9) and (21) indicated below.
4. ☒ The US has been elected by the expiration of 19 months from the priority date (Article 31).
5. ☒ A copy of the International Application as filed (35 U.S.C. 371(c)(2))
   a. ☐ is attached hereto (required only if not communicated by the International Bureau).
   b. ☒ has been communicated by the International Bureau.
   c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US).
6. ☒ An English language translation of the International Application as filed (35 U.S.C. 371(c)(2))
   a. ☒ is attached hereto.
   b. ☐ has been previously submitted under 35 U.S.C. 154(d)(4).
7. ☒ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3))
   a. ☐ are attached hereto (required only if not communicated by the International Bureau).
   b. ☐ have been communicated by the International Bureau.
   c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.
   d. ☒ have not been made and will not be made.
8. ☐ An English language translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
9. ☐ An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).
10. ☐ An English language translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

Items 11 to 20 below concern document(s) or information included:

11. ☒ An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
12. ☐ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
13. ☒ A FIRST preliminary amendment.
14. ☐ A SECOND or SUBSEQUENT preliminary amendment.
15. ☐ A substitute specification.
16. ☐ A change of power of attorney and/or address letter.
17. ☐ A computer-readable form of the sequence listing in accordance with PCT Rule 13ter.2 and 35 U.S.C. 1.821 - 1.825.
18. ☐ A second copy of the published international application under 35 U.S.C. 154(d)(4).
19. ☐ A second copy of the English language translation of the international application under 35 U.S.C. 154(d)(4).
20. ☒ Other items or information:

Publ. Appln. No. WO 01/26069; PCT Forms IPEA/416, RO/105, IB/301, IB/332, RO/101; One (1) sheet of drawing; German text as originally filed, and German text (after Chapter II); English translation of the application as originally filed; English translation of the application (after Chapter II) (Amended Sheets Only).

21839

JC10 Rec'd PCT/PTO 01 APR 2002

U.S. APPLICATION NO (If known, see 37 C.F.R. 1.5)	INTERNATIONAL APPLICATION NO	ATTORNEY'S DOCKET NUMBER
Unassigned 10/089606	PCT/CH00/00459	004501-653

21. ☒ The following fees are submitted:	CALCULATIONS	PTO USE ONLY
Basic National Fee (37 CFR 1.492(a)(1)-(5)):		
Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO and International Search Report not prepared by the EPO or JPO $1,040.00 (960)		
International preliminary examination fee (37 CFR 1.482) not paid to USPTO but International Search Report prepared by the EPO or JPO $890.00 (970)		
International preliminary examination fee (37 CFR 1.482) not paid to USPTO but international search fee (37 CFR 1.445(a)(2)) paid to USPTO $740.00 (958)		
International preliminary examination fee (37 CFR 1.482) paid to USPTO but all claims did not satisfy provisions of PCT Article 33(1)-(4) $710.00 (956)		
International preliminary examination fee (37 CFR 1.482) paid to USPTO and all claims satisfied provisions of PCT Article 33(1)-(4) $100.00 (962)		
ENTER APPROPRIATE BASIC FEE AMOUNT =	$ 890.00	
Surcharge of $130.00 (154) for furnishing the oath or declaration later than 20 ☐ 30 ☐ months from the earliest claimed priority date (37 CFR 1.492(e)).	$	

Claims	Number Filed	Number Extra	Rate		
Total Claims	10 -20 =		X$18.00 (966)	$	
Independent Claims	2 -3 =		X$84.00 (964)	$	
Multiple dependent claim(s) (if applicable)			+$280.00 (968)	$	
TOTAL OF ABOVE CALCULATIONS =				$ 890.00	
Reduction for 1/2 for filing by small entity, if applicable (see below).			+	$	-
SUBTOTAL =				$ 890.00	
Processing fee of $130.00 (156) for furnishing the English translation later than 20 ☐ 30 ☐ months from the earliest claimed priority date (37 CFR 1.492(f)).			+	$	
TOTAL NATIONAL FEE =				$ 890.00	
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). $40.00 (581) per property			+	$	
TOTAL FEES ENCLOSED =				$ 890.00	
				Amount to be refunded:	$
				charged:	$

a. ☐ Small entity status is hereby claimed.

b. ☒ A check in the amount of $ 890.00 to cover the above fees is enclosed.

c. ☐ Please charge my Deposit Account No. 02-4800 in the amount of $_____ to cover the above fees. A duplicate copy of this sheet is enclosed.

d. ☒ The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. 02-4800. A duplicate copy of this sheet is enclosed.

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.

SEND ALL CORRESPONDENCE TO:

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Robert S. Swecker
NAME

19,885 — April 1, 2002
REGISTRATION NUMBER — DATE

Patent
Attorney's Docket No. 004501-653

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re Patent Application of	
STEFAN RAMSEIER, et al.	Group Art Unit: Unassigned
Application No.: Unassigned	Examiner: Unassigned
Filed: April 1, 2002	
For: SENSOR COMPRISING WIRELESS DATA TRANSFER UNIT WITH A LOW POWER UPTAKE	

PRELIMINARY AMENDMENT

Assistant Commissioner for Patents
Washington, D.C. 20231

Sir:

Prior to examination of the above-captioned patent application, applicants request that the following claim amendments be entered.

IN THE CLAIMS:

Please replace Claims 1-10 as follows.

1. (Amended) A method for wireless transmission of data by a sensor unit of a sensor via a communication unit to a base station, wherein the communication unit

a) receives a wake-up signal for the sensor unit,

b) transfers from a sleep mode into an active mode,

c) sends a modulated data signal to the base station,

d) awaits the reception of a modulated acknowledgement signal,

e) transfers from the active mode to the sleep mode in the case of the reception of the modulated acknowledgement signal,

and wherein the communication unit

f) sends a modulated data signal again in the case of no reception of the modulated acknowledgement signal and continues in accordance with step d).

and wherein the communication unit sends the modulated data signal in step c) by virtue of the fact that the communication unit switches on a receiver of the communication unit, awaits the reception of a modulated synchronization signal, and sends the modulated data signal following a prescribed time after reception of the modulated synchronization signal.

2. (Amended) The method as claimed in claim 1, wherein the communication unit sends the modulated data signal in step c) in a time window that is determined with the aid of an internal clock.

3. (Amended) The method as claimed in claim 1, wherein, in the case of a reception of a modulated data signal in a first time window, the base station sends a single modulated acknowledgement signal in a second time window following the first.

4. (Amended) The method as claimed in claim 1, wherein, after the reception of modulated data signals of a plurality of sensors, the base station sends, one after another, modulated acknowledgement signals assigned to these sensors without there being data signals between the acknowledgement signals.

5. (Amended) The method as claimed in claim 1, wherein modulated data signals and modulated acknowledgement signals are transmitted on different carrier frequencies.

6. (Amended) The method as claimed in claim 1, wherein the communication unit receives the wake-up signal and a data signal from a proximity sensor, in particular from a proximity switch.

7. (Amended) The method as claimed in claim 6, wherein the sensor unit operates on the basis of a capacitive, inductive or photoelectric operating principle or a Hall effect, or on the basis of ultrasound.

8. (Amended) A device for wireless transmission of data from a sensor unit via a communication unit to a base station, the communication unit having a receiver for receiving a modulated synchronization signal and for receiving a modulated acknowledgement signal, and a transmitter for sending a modulated data signal, and the receiver and the transmitter both having an active mode and a sleep mode, the device having a sleep unit for switching over the mode of the receiver and transmitter in accordance with a wake-up signal from the sensor unit, and of an acknowledgement signal from the receiver, wherein the transmitter has means for repeatedly sending a modulated data signal in accordance with a negative acknowledgement signal from the receiver, and the receiver has means for awaiting reception of a modulated synchronization signal after

reception of the wake-up signal of the sensor unit, and for generating a synchronization signal for the purpose of temporal synchronization of the modulated data signal.

9. (Amended) The device as claimed in claim 8, wherein the device is assigned a prescribed time delay between the reception of the modulated synchronization signal and the sending of the modulated data signal.

10. (Amended) The device as claimed in claim 8, wherein the sensor unit is a proximity sensor or a proximity switch.

REMARKS

By way of the foregoing amendments to the claims, Claims 1-10 have been amended to delete the reference numerals and to replace the words "characterized in that" with the word "wherein". These changes have been made in accordance with 37 C.F.R. § 1.121 as amended on November 7, 2000. Marked-up versions of Claims 1-10 indicating the changes accompany this Preliminary Amendment.

Early and favorable consideration with respect to this application is respectfully requested.

Should any questions arise in connection with this application, the undersigned respectfully requests that he be contacted at the number indicated below.

Respectfully submitted,

BURNS, DOANE, SWECKER & MATHIS, L.L.P.

By: _____

Robert S. Swecker
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Date: April 1, 2002

Attachment to Preliminary Amendment dated April 1, 2002

Marked-up Claims 1-10

1. (Amended) A method for wireless transmission of data by a sensor unit [(15)] of a sensor [(1)] via a communication unit [(10)] to a base station, [in the case of which] wherein the communication unit [(10)]

a) receives a wake-up signal [(w)] for the sensor unit [(15)],

b) transfers from a sleep mode into an active mode,

c) sends a modulated data signal [(d_m)] to the base station,

d) awaits the reception of a modulated acknowledgement signal [(ACK_m)],

e) transfers from the active mode to the sleep mode in the case of the reception of the modulated acknowledgement signal [(ACK_m)],

[characterized in that] and wherein the communication unit [(10)]

f) sends a modulated data signal [(d_m)] again in the case of no reception of the modulated acknowledgement signal [(ACK_m)] and continues in accordance with step d).

and [in that] wherein the communication unit [(10)] sends the modulated data signal [(d_m)] in step c) by virtue of the fact that the communication unit [(10)] switches on a receiver [(13)] of the communication unit [(10)], awaits the reception of a modulated synchronization signal [(21)], and sends the modulated data signal [(d_m)] following a prescribed time after reception of the modulated synchronization signal [(21)].

Attachment to Preliminary Amendment dated April 1, 2002

Marked-up Claims 1-10

2. (Amended) The method as claimed in claim 1, [characterized in that] wherein the communication unit [(10)] sends the modulated data signal [(d_m)] in step c) in a time window [(22)] that is determined with the aid of an internal clock.

3. (Amended) The method as claimed in claim 1, [characterized in that] wherein, in the case of a reception of a modulated data signal [(d_m)] in a first time window [(22)], the base station sends a single modulated acknowledgement signal [(ACK_m)] in a second time window [(22)] following the first.

4. (Amended) The method as claimed in claim 1, [characterized in that] wherein, after the reception of modulated data signals [(d_m)] of a plurality of sensors [(1)], the base station sends, one after another, modulated acknowledgement signals [(ACK_m)] assigned to these sensors [(1)] without there being data signals between the acknowledgement signals.

5. (Amended) The method as claimed in claim 1, [characterized in that] wherein modulated data signals [(d_m)] and modulated acknowledgement signals [(ACK_m)] are transmitted on different carrier frequencies.

Attachment to Preliminary Amendment dated April 1, 2002

Marked-up Claims 1-10

6. (Amended) The method as claimed in claim 1, [characterized in that] wherein the communication unit [(10)] receives the wake-up signal [(w)] and a data signal [(d)] from a proximity sensor, in particular from a proximity switch.

7. (Amended) The method as claimed in claim 6, [characterized in that] wherein the sensor unit [(3)] operates on the basis of a capacitive, inductive or photoelectric operating principle or a Hall effect, or on the basis of ultrasound.

8. (Amended) A device for wireless transmission of data from a sensor unit [(15)] via a communication unit [(10)] to a base station, the communication unit [(10)] having a receiver [(13)] for receiving a modulated synchronization signal [(21)] and for receiving a modulated acknowledgement signal [(ACK_m)], and a transmitter [(12)] for sending a modulated data signal [(d_m)], and the receiver [(13)] and the transmitter [(12)] both having an active mode and a sleep mode, the device having a sleep unit [(14)] for switching over the mode of the receiver [(13)] and transmitter [(12)] in accordance with a wake-up signal [(w)] from the sensor unit [(15)], and of an acknowledgement signal [(ACK)] from the receiver [(13)], [characterized in that] wherein the transmitter [(12)] has means for repeatedly sending a modulated data signal [(d_m)] in accordance with a negative acknowledgement signal [(nACK)] from the receiver, and the receiver [(13)] has means for awaiting reception of a modulated synchronization signal [(21)] after reception of the wake-up signal [(w)] of the

Attachment to Preliminary Amendment dated April 1, 2002

Marked-up Claims 1-10

sensor unit [(15)], and for generating a synchronization signal [(sync)] for the purpose of temporal synchronization of the modulated data signal [(d_m)].

9. (Amended) The device as claimed in claim 8, [characterized in that] wherein the device is assigned a prescribed time delay between the reception of the modulated synchronization signal [(21)] and the sending of the modulated data signal [(d_m)].

10. (Amended) The device as claimed in claim 8, [characterized in that] wherein the sensor unit [(15)] is a proximity sensor or a proximity switch.

Sensor with wireless data transmission having low power consumption

DESCRIPTION

Technical Field

The invention relates to the field of communications technology. It relates to a method and a device for wireless transmission of data from a sensor to a base station in accordance with the preamble of patent claims 1 and 9.

Prior Art

Sensors, in particular proximity sensors, are generally known and are used in automation installations, production systems and production engineering systems. Proximity sensors permit measurement of liquid levels or of positions of workpieces or machine paths. Proximity switches permit detection of the presence or absence of liquids, workpieces or machine parts. In order to eliminate the cabling of sensors, something which is advantageous in the case of a multiplicity of sensors, sensors transmit their measured data without cables by radio.

Battery operated units frequently have what is termed a sleep mode, in order to reduce their power consumption. In the case of wireless communication systems, transmitters and receivers are switched off during the sleep mode and are activated only periodically. For autonomous sensors that are intended to transmit sensor values in a wireless fashion to a base station, the task arises of accomplishing this with as low a consumption of energy as possible, there being a need to ensure reliable transmission of the sensor values.

A method for transmitting data to stations of a wireless communication network is disclosed in EP-A-0 907 262. In this case, a central unit transmits wake-up signals with the aid of which stations that are intended to receive data are switched over from an energy-saving sleep mode to an active mode. In the active mode, a station determines whether data are to be transmitted and transmits these if necessary. Consequently, the station frequently passes into the energy-consuming active mode even when no data are to be transmitted. If a station wants to transmit data, the transmission is delayed by awaiting a wake-up signal.

A time division multiple access (TDMA) method is generally known. It permits a controlled and deterministic access to a communication medium and described, for example, in EP-A-0 899 920. TDMA is used, for example, for satellite connections, mobile communication means (GSM) and radio telephones.

Summary of the Invention

It is an object of the invention to create a method and a device having a low power consumption for the purpose of wireless transmission of data from a sensor to a base station that eliminate the above-named disadvantages.

This object is achieved by a method and a device having low power consumption for wireless transmission of data form a sensor to a base station and having the features of patent claims 1 and 9.

In the method according to the invention, a communication unit receives a wake-up signal from an assigned sensor unit and transfers from an energy-saving sleep mode to an active mode. A receiver

of the communication unit receives and detects a cyclically recurring modulated synchronization signal emitted by a base station. At a prescribed time after this detection, a transmitter of the communication unit sends a modulated data signal. The receiver awaits the reception of a modulated acknowledgement signal. If such a signal is received, the communication unit transfers to the sleep mode. Otherwise, the modulated data signal is sent repeatedly in recurring time windows assigned to the communication unit until a modulated acknowledgement signal is received.

According to the invention, thus, the communication unit is put into the active or sleep mode, respectively, by signals of different provenance.

The method according to the invention has the advantage that a more energy-consuming mode of the communication unit occurs only when data have to be transmitted, and that a switchover is made to the sleep mode again only after a successful transmission.

A further advantage is that the communication unit transfers immediately into the active mode upon the occurrence of sensor data, without having to await a wake-up signal from the base station. Since synchronization signals can be transmitted more often than would be sensible for external wake-up signals, sensor data are transmitted more quickly to the base station.

In a preferred variant of the invention, the sensor is a proximity sensor or a proximity switch. The sensor is preferably an inductive, capacitive, photoelectric or ultrasonic or Hall sensor.

Further preferred embodiments follow from the dependent patent claims.

Brief Description of the Drawings

The subject matter of the invention is explained in more detail below with the aid of a preferred exemplary embodiment that is illustrated in the attached drawings, in which:

figure 1 shows a schematic of a sensor according to the invention;
figure 2 shows a signalling frame;
figure 3 shows a schematic of a cycle of the method according to the invention; and
figure 4 shows individual time windows from a signalling frame.

The reference symbols used in the drawings and their meaning are listed in summary in the list of reference symbols. Basically, identical parts are provided in the figures with identical reference symbols.

Ways of implementing the Invention

Figure 1 shows a schematic of a functional structure of a sensor 1 according to the invention with a communication unit 10 and an assigned sensor unit 15. The communication unit 10 has an antenna 11 for electromagnetic waves that is connected to a transmitter 12 and a receiver 13, and a sleep unit 14. The communication unit 10 has signal connections for transmitting a synchronization signal sync and a negative acknowledgement signal nACK from the receiver 13 to the transmitter 12, a signal connection for transmitting an acknowledgement signal ACK from the receiver 13 to the sleep unit 14, a signal connection for transmitting a wake-up/sleep signal w/s from the sleep unit 14 to the transmitter 12 and to the receiver 13, a signal connection for transmitting a wake-up signal w from the sensor unit 15 to the sleep unit 14,

and a data connection for transmitting a data signal d from the sensor unit 15 to the transmitter 12. The communication unit 10, in particular the transmitter 12 and the receiver 13, have an active mode for transmitting data, and a sleep mode in which they consume little or no power.

The communication is based on a time division multiplex method, the TDMA (Time Division Multiple Access) method. Such methods are generally known and are used in mobile telephony. The time cycle of a data transmission in a TDMA system is illustrated in figure 2 along a time axis t. A base station sends in a time interval 21 a synchronization signal that is, for example, modulated onto a carrier frequency. One or more sensors or communication units 10 of a TDMA communication system receive this modulated synchronization signal and thereby identify an initial instant of a temporal signalling frame 20. Each of a plurality of sensors 1 is assigned at least one time window 22 inside this signalling frame 20, that is to say a time delay between an initial instant of the signalling frame 20, or the reception of the modulated synchronization signal 21, and an initial instant of the time window 22. The information on this assignment or delay is stored in the communication unit 10 of the sensor 1 and in the base station.

Figure 3 shows a time sequence of signals triggered in the method according to the invention. It is assumed in order to explain the method that the communication unit 10 of a sensor 1 is in the sleep mode. The assigned sensor unit 15 experiences a change of state and thereupon transmits a wake-up signal w to the sleep unit 14 and applies a data signal d to the data connection with a transmitter 12. On the basis of the wake-up signal w, the sleep unit 14 generates a wake-up signal w/s for the transmitter 12 and receiver 13,

whereupon these transfer from the sleep mode to the active mode. Via an antenna 11, the receiver receives a signal, for example, on a known carrier frequency, and searches therein for the modulated synchronization signal 21, for example by correlating the received signal with a stored version of the modulated synchronization signal. If this is found, the receiver 13 transmits the synchronization signal sync to the transmitter 12. The known position of the time window 22, assigned to the sensor 1, inside the signalling frame 20 yields the prescribed time delay between the reception of the modulated synchronization signal 21 and the assigned time window 22. After this delay time, the transmitter transmits a modulated version d_m of the data signal d in the time window of the sensor 1 via the antenna 11.

In a preferred variant of the invention, if the receiver 13 receives no modulated synchronization signal 21 after the transfer from the sleep to the active mode, for example owing to interference, the time window 22 for transmitting the modulated data signal d_m is determined with the aid of an internal clock of the communication unit 10. The internal clock is synchronized with the aid of modulated synchronization signals 21 of the base station, or with the aid of another time signal, of the global positioning system (GPS).

If the base station receives the modulated data signal d_m of a specific sensor 1, it sends a modulated acknowledgement signal ACK_m.

In a preferred variant of the method according to the invention, this is performed if the base station receives a modulated data signal d_m in a first time window 22 by virtue of the fact that it sends an individual modulated acknowledgement signal ACK_m only

in a second time window 22, following the first. This situation is illustrated in figure 4:

- a second modulated data signal d_m(n) is transmitted from a second sensor 1 to the base station,
- subsequently, a possible first modulated acknowledgement signal ACK_m(n-1) of a preceding, first modulated data signal is transmitted from the base station to a first sensor 1,
- subsequently, a third modulated data signal d_m(n+1) is transmitted from a third sensor 1 to the base station,
- and, finally, a second modulated acknowledgement signal ACK_m(n) of the reception of the second modulated data signal d_m(n) is transmitted from the base station to the second sensor 1.

This cycle has the advantage that the base station has sufficient time to decide whether a modulated data signal really has been received in a time window 22. In a further variant of the inventive method, the modulated acknowledgement signal is sent in the k-th time window 22, which follows the time window 22 in which the associated modulated data signal was received, k being greater than one. The value k=1 corresponds to the cycle, described in detail above, with the delay of the acknowledgement by the duration of a time window 22. The acknowledgements of the data signals that were received in the last k time windows 22 of a signalling frame 20 are performed in this case preferably in the first k time windows 22 of the signalling frame 20 following thereupon.

In another advantageous variant of the method according to the invention, the modulated acknowledgement signals ACK_m for all sensors 1 are transmitted as a group of modulated acknowledgement signals without modulated signals d_m lying between the modulated acknowledgement signals ACK_m. This group is transmitted with the aid

of a fixed time shift with reference to the modulated synchronization signal 21, for example at the end of a signalling frame 20, or subsequent to the transmission of the modulated synchronization signal 21.

In a further advantageous variant of the invention, the modulated acknowledgement signals ACK_m are transmitted on another carrier frequency than the modulated data signals d_m.

If the transmission of a modulated data signal d_m by the transmitter 12 of a sensor 1 to the base station does not succeed owing to whatever sort of interference, the data is lost. In order, nevertheless, to ensure reliable transmission of the data, a communication unit 10 repeatedly sends its data in consecutive signalling frames 20 until it receives the assigned modulated acknowledgement signal. The communication unit 10 transfers to the sleep mode again only after the reception of this acknowledgement.

An example for such a cycle is shown again in figure 3: after a first transmission of a modulated data signal d_m, the receiver 13 receives no modulated acknowledgement signal ACK_m. Thereupon, the receiver 13 transmits a negative acknowledgement signal nACK to the transmitter 12. If the modulated acknowledgement signal ACK_m is being awaited in the time window 22 that follows the modulated data signal d_m, the negative acknowledgement signal nACK can already be generated after this time window 22, as illustrated in figure 3. In the other variants of the invention described above, in which the modulated acknowledgement signal ACK_m is not awaited until later, the negative acknowledgement signal nACK is also generated correspondingly later. In the case of each of these variants, the transmitter 12 resends the modulated data signal d_m in the next signalling frame 20 in the time

window 22 that is assigned to the sensor 10. If the receiver 13 thereupon receives a modulated acknowledgement signal ACK_m, as shown in figure 3, it transmits an acknowledgement signal ACK to the sleep unit 14, whereupon the sleep unit 14 generates a sleep signal w/s for the transmitter 12 and receiver 13, whereupon these transfer from the active mode to the sleep mode.

In the case of the above described repeated sending of modulated data signals d_m, accurate start times of corresponding time windows 22 are advantageously determined with the aid of the modulated synchronization signals 21 present in each signalling frame. For the case in which such a modulated synchronization signal 21 is not received, the start instant of a time window 22 is advantageously determined with the aid of the internal clock of the communication unit 10. The internal clock is synchronized upon reception of a modulated synchronization signal 21.

In a preferred embodiment of the invention, the sensor is a proximity sensor or a proximity switch, and the functioning of the sensor unit 15 is based, for example, on a capacitive, inductive or photoelectric operating principle, or on a Hall effect or on ultrasound.

The method according to the invention preferably uses sensor sampling rates of 1 Hz to 4 kHz, carrier frequencies in the range of 100 kHz to 5 GHz, and data rates from 1000 bit/s to 10 Mbit/s.

In particular, carrier frequencies in an ISM (Industrial/Scientific/Medical) frequency band are preferred, since no radio licenses are required for this purpose, for example at a frequency of at least

approximately 2.4 GHz. The sensor sampling rate is preferably at least approximately 1 kHz, a frame length of a signalling frame 20 is at least approximately 1.25 milliseconds or at least approximately 5 milliseconds, and a slot duration of a time window 22 is at least approximately 39 microseconds.

A further preferred variant of the invention has a plurality of base stations that are respectively assigned various groups or sensors (1). In order to avoid interference, the various groups advantageously use different frequency bands and/or different synchronization sequences.

List of Reference Symbols

1	Sensor
10	Communication unit
11	Antenna
12	Transmitter Tx
13	Receiver Rx
14	Sleep unit CHRR
15	Sensor unit S
20	Signalling frame
21	Modulated synchronization signal
22	Time window
w	Wake-up signal
w/s	Wake-up/sleep signal
synch	Synchronization signal
d	Data signal
d_m	Modulated data signal
ACK	Acknowledgement signal
nACK	Negative acknowledgement signal
ACK_m	Modulated acknowledgement signal
t	Time axis

PATENT CLAIMS

1. A method for wireless transmission of data by a sensor unit (15) of a sensor (1) via a communication unit (10) to a base station, in the case of which the communication unit (10)
   a) receives a wake-up signal (w) for the sensor unit (15),
   b) transfers from a sleep mode into an active mode,
   c) sends a modulated data signal (d_m),
   d) awaits the reception of a modulated acknowledgement signal (ACK_m),
   e) transfers from the active mode to the sleep mode in the case of the reception of the modulated acknowledgement signal (ACK_m), and
   f) sends a modulated data signal (d_m) again in the case of no reception of the modulated acknowledgement signal (ACK_m) and continues in accordance with step d).

2. The method as claimed in claim 1, characterized in that the communication unit (10) sends the modulated data signal (d_m) in step c) by virtue of the fact that the communication unit (10) switches on a receiver (13) of the communication unit (10), awaits the reception of a modulated synchronization signal (21), and sends the modulated data signal (d_m) following a prescribed time after reception of the modulated synchronization signal (21).

3. The method as claimed in claim 1, characterized in that the communication unit (10) sends the modulated data signal (d_m) in step c) in a time window (22) that is determined with the aid of an internal clock.

4. The method as claimed in claim 1, characterized in that, in the case of a reception of a modulated data signal (d_m) in a first time window (22), the base station sends a single modulated acknowledgement signal (ACK_m) in a second time window (22) following the first.

5. The method as claimed in claim 1, characterized in that, after the reception of modulated data signals (d_m) of a plurality of sensors (1), the base station sends, one after another, modulated acknowledgement signals (ACK_m) assigned to these sensors (1) without there being data signals between the acknowledgement signals.

6. The method as claimed in claim 1, characterized in that modulated data signals (d_m) and modulated acknowledgement signals (ACK_m) are transmitted on different carrier frequencies.

7. The method as claimed in claim 1, characterized in that the communication unit (10) receives the wake-up signal (w) and a data signal (d) from a proximity sensor, in particular from a proximity switch.

8. The method as claimed in claim 7, characterized in that the sensor unit (3) operates on the basis of a capacitive, inductive or photoelectric operating principle or a Hall effect, or on the basis of ultrasound.

9. A device for wireless transmission of data from a sensor unit (15) via a communication unit (10) to a base station, the communication unit (10) having a receiver (13) for receiving a modulated synchronization signal (21) and for receiving a modulated acknowledgement signal (ACK_m), and a

transmitter (12) for sending a modulated data signal (d_m), and the receiver (13) and the transmitter (12) both having an active mode and a sleep mode, characterized in that the device has a sleep unit (14) for switching over the mode of the receiver (13) and transmitter (12) in accordance with a wake-up signal (w) from the sensor unit (15), and of an acknowledgement signal (ACK) from the receiver (13), and in that the transmitter (12) has means for repeatedly sending a modulated data signal (d_m) in accordance with a negative acknowledgement signal (nACK) from the receiver, and the receiver (13) has means for receiving a modulated synchronization signal (21) and for generating a synchronization signal (sync) for the purpose of temporal synchronization of the modulated data signal (d_m).

10. The device as claimed in claim 9, characterized in that the device is assigned a prescribed time delay between the reception of the modulated synchronization signal (21) and the sending of the modulated data signal (d_m).

11. The device as claimed in claim 9, characterized in that the sensor unit (15) is a proximity sensor or a proximity switch.

ABSTRACT

In the method according to the invention, a communication unit (10) of a sensor (1) receives a wake-up signal (w) from an assigned sensor unit (15), and transfers from an energy-saving sleep mode to an active mode. A receiver (13) of the communication unit (10) detects a cyclically occurring modulated synchronization signal of a base station, whereupon a transmitter (12) sends a modulated data signal following a prescribed time. The receiver (13) awaits the reception of a modulated acknowledgement signal. If such a signal is received, the communication unit (10) transfers into the sleep mode. Otherwise, the modulated data signal is repeatedly sent in the recurring time windows assigned to the sensor (1), until a modulated acknowledgement signal is received.

The method according to the invention has the advantage that an energy-consuming mode of the communication unit (10) occurs only when it is necessary to transmit data, and that a switchover is made again to the sleep mode only after a successful transmission.

(Figure 1)

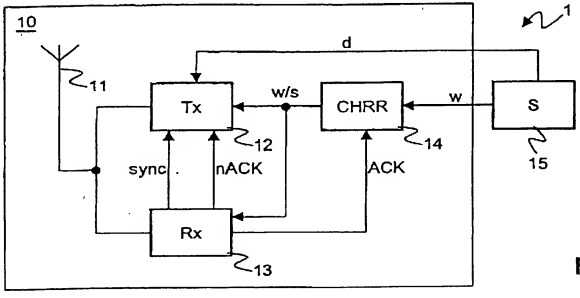

Fig. 1

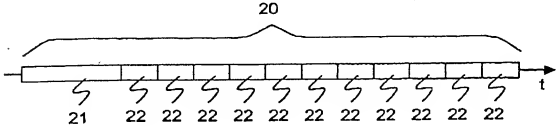

Fig. 2

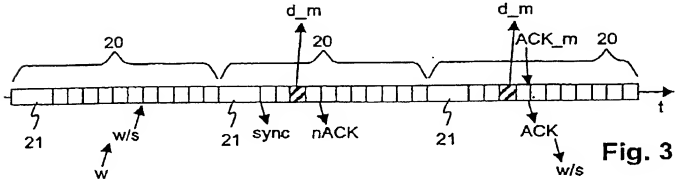

Fig. 3

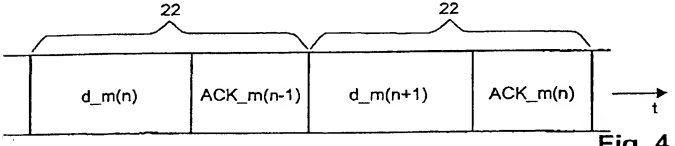

Fig. 4

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As a below named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name;

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled:

Sensor with wireless data transmission having low power consumtion

the specification of which **(check only one item below)**:

☐ is attached hereto.

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Number **10/089,606** on **01.04.2002**
and was amended on _____ (if applicable).

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I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose to the Office all information known to me to be material to patentability as defined in Title 37, Code of Federal Regulations, § 1.56.

I hereby claim foreign priority benefits under Title 35, United States Code, § 119 (a)-(d) of any foreign application(s) for patent or inventor's certificate or of any PCT international application(s) designating at least one country other than the United States of America listed below and have also identified below any foreign application(s) for patent or inventor's certificate or any PCT international application(s) designating at least one country other than the United States of America filed by me on the same subject matter having a filing date before that of the application(s) of which priority is claimed:

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COUNTRY (if PCT, indicate "PCT")	APPLICATION NUMBER	DATE OF FILING (day, month, year)	PRIORITY CLAIMED UNDER 35 U.S.C. §119
Germany	**199 47 344.7**	**01.10.1999**	☒Yes ☐No
			☐Yes ☐No
			☐Yes ☐No
			☐Yes ☐No
			☐Yes ☐No

Combined Declaration for Patent Application and Power of Attorney
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I hereby appoint the following attorneys and agent(s) to prosecute said application and to transact all business in the U.S. Patent and Trademark Office connected therewith and to file, prosecute and to transact all business in connection with international applications directed to said invention:

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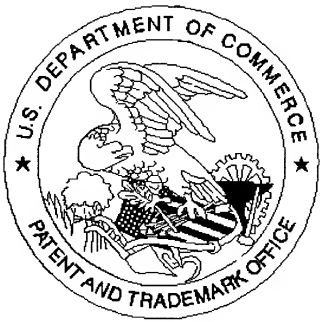

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